



Economics at the FCC 2020–21: Closing the Connectivity Gap, COVID-19 and Telehealth, Spectrum Auctions, Communications Marketplace Report, and Economic Research

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Abstract

The U.S. Federal Communications Commission is responsible for regulation in the communications marketplace and for management of the nation’s non-federal radio frequency spectrum. During the past year, FCC economists assisted in the development of initiatives that were aimed at closing the connectivity gap which proved especially critical in light of the COVID-19 pandemic; contributed to the Commission’s extensive responses to COVID-19; were involved in various spectrum auctions; evaluated competition in the communications marketplace in the *2020 Communications Marketplace Report*; and published a series of working papers.

Keywords FCC · Closing the connectivity gap · Communications marketplace report · COVID-19 and telehealth · OEA working papers · Spectrum auctions · Telecommunications policy

1 Introduction

The U.S. Federal Communications Commission (FCC) is an independent regulatory agency that is responsible for regulating interstate and international wired, wireless, and satellite communications and domestic electronic media (TV, radio, cable, DBS) in addition to public safety communications. Further, the FCC administers the allocation and assignment of licenses for non-federal use of the radio spectrum.

The cornerstone of the FCC’s mission—which is enshrined in the 1934 Communications Act—is to ensure that all Americans have access to rapid and efficient

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communications services nationwide.¹ The 1996 Telecommunications Act preserved and expanded this universal service mandate by directing the FCC to create programs to support communications services to high-cost areas, rural health-care providers, schools and libraries, and low-income households, and to expand eligible services beyond ordinary voice telephone service to include access to high-speed internet service. The onset of the COVID-19 pandemic in 2020 elevated the importance of universal broadband as critical for the nation's health and the economy.

In Sect. 2, we first describe the FCC's Broadband Data Collection which is intended to improve its collection of broadband data and production of broadband maps. We then explain how the FCC implemented various emergency programs as part of its efforts to close the broadband connectivity gap in light of the COVID-19 pandemic.

Section 3 reviews the FCC's continuing process of designing electromagnetic spectrum auction mechanisms to address increasingly complex situations. For example, the FCC continues to reallocate licensed spectrum to new uses which requires the FCC staff to design auctions that incentivize incumbent licensees to yield their spectrum to other users when it is efficient to do so. Additionally, economists have supported the FCC's ongoing efforts to improve broadband connectivity in rural America by designing and implementing "reverse auctions" to award funding to private providers to build out wired and wireless broadband facilities in high-cost rural areas.

Section 4 summarizes the contents of the second biennial "Communications Marketplace Report" which was published at the end of 2020. This report is one of many regular reports that the FCC produces under statutory mandate. Finally, Sect. 5 briefly describes three economic working papers that were released during this year.

2 Closing the Connectivity Gap and the COVID-19 Pandemic

Section 2.1 describes the FCC's efforts to improve its broadband coverage data, while Sect. 2.2 describes various actions that both Congress and the FCC took to ensure that residential customers—including low-income customers—could secure or retain their broadband connections.

In brief, since the onset of the COVID-19 pandemic, Congress has passed several laws to aid Americans. For example, the Coronavirus Aid, Relief, and Economic Security (CARES) Act created the COVID-19 Telehealth Program which disbursed \$200 million to help healthcare providers deliver connected care services to patients at their homes or mobile locations.² A second round of \$250 million in funding was appropriated by the Consolidated Appropriations Act.³ That bill also appropriated

¹ 47 U.S.C. Sect. 151.

² Coronavirus Aid, Relief, and Economic Security Act, Pub. L. No 116–136, 134 Stat. 281 (2020) (CARES Act).

³ Consolidated Appropriations Act, 2021, Pub. L. No: 116–260, Division N-Additional Coronavirus Response and Relief, Title IX-Broadband Internet Access Service, § 903 "FCC COVID-19 Telehealth Program" (2020), available at <https://www.congress.gov/bill/116th-congress/house-bill/133/text> (Consolidated Appropriations Act).

\$3.2 billion for the Emergency Broadband Benefits Program to reduce the cost of broadband service and certain connected devices for eligible low-income households during the health emergency.⁴

The FCC took immediate actions to ensure reliable and accessible broadband. For example, the FCC eased enrollment requirements and paused de-enrollment rules of its Lifeline program to ensure that low-income households could stay connected (FCC, 2021a).⁵

2.1 Measuring the Gap Through Improved Coverage Maps

Stay-at-home orders and other state and local measures relocated Americans' online activity from work, schools, and public places to their homes which caused dramatic shifts in usage patterns (BITAG, 2021). The need to work and learn from home led to robust growth of broadband subscriptions, but it also exposed persistent connectivity gaps among certain segments of the population (Iyengar & Bergman, 2020).

To close the connectivity gap efficiently, the FCC must have accurate information about which areas of the country have adequate broadband access and which areas do not. Currently, the information that is submitted by broadband providers on the FCC's Form 477 is the primary data source for many FCC actions, including: (1) satisfying its statutory obligation to report annually on the state of broadband availability; (2) updating the FCC's universal service policies and monitoring whether its universal service goals are being achieved in a cost-effective manner; (3) meeting various public safety obligations; and (4) maintaining coverage maps to inform stakeholders, including industry and the public. (FCC, 2019a, p. 4; Boliek et al., 2019).

The Form 477 data, however, are not sufficient to enable the FCC to meet its Universal Service Fund (USF) policy goals (FCC, 2019a, p. 5). Responding to this need for better broadband information, the FCC initiated a new data collection program in 2019 that was "distinct from the existing Form 477 collection" and that would "gather geospatial broadband service availability data specifically targeted toward advancing our universal service goals" (FCC, 2019a, p. 2). Following adoption of the first order, Congress passed the Broadband Deployment Accuracy and Technological Availability Act (Broadband DATA Act) in March 2020.⁶ This Act required the FCC to take additional steps to improve its broadband data collection and the maps that document broadband availability.

In July 2020, the FCC adopted rules to make its new data collection consistent with requirements of the Broadband DATA Act (FCC, 2020a). In the second order,

⁴ The American Rescue Plan Act of 2021 created the Emergency Connectivity Fund which set aside \$7.171 billion in funding for remote learning (FCC, 2021b).

⁵ The FCC also issued various grants of Special Temporary Authority (STA) that gave wireless service providers access to licensed spectrum that is held in Commission inventory or by other entities to provide their services—including hundreds of STAs granted on Tribal lands. See, e.g., <https://docs.fcc.gov/public/attachments/DOC-363378A1.pdf>.

⁶ Broadband Deployment Accuracy and Technological Availability Act (Broadband DATA Act). (2020). Pub. L. 116–130; 47 USC Sect. 642 *et. Seq.*

the FCC, among other things, adopted rules that govern: (1) reporting standards for fixed and mobile services; (2) requirements for the first comprehensive data set of broadband serviceable structures in all 50 states which is called the “Fabric”; and (3) processes for verifying data that are collected from providers—including certification requirements, regular FCC audits, and the inclusion of crowdsourced data (FCC, 2020a).⁷

In January 2021, the FCC adopted a third order which, among other things: (1) specified that facilities-based fixed service providers are required to report broadband Internet access service; (2) required those providers to identify where such services are offered to residential locations and where they are offered to business locations; (3) established reporting requirements for speed and latency for fixed service providers; (4) required mobile broadband providers to provide additional information concerning their networks and propagation which should assist the FCC in verifying coverage; (5) established requirements for challenges to fixed and mobile coverage data and for challenges to the Fabric; and (6) adopted standards for identifying locations that will be included in the Fabric (FCC, 2021c, p. 5). Subsequently, Acting Chairwoman Jessica Rosenworcel established a Broadband Data Task Force that is dedicated to implementing the rules and data collection (FCC, 2021d).

Once it is implemented, the new data collection should provide the FCC with more precise and accurate broadband coverage data by adopting standardized, granular reporting requirements for broadband providers, and by giving the FCC numerous additional sources of data and the means to verify the providers’ submissions. These supplementary data sources include: verification data that are supplied by the providers themselves (*e.g.*, drive test data⁸ or infrastructure data); data that are supplied by state, local, and Tribal governments; data that are received through the FCC-established process that permits state, local, and Tribal governments—as well as the public—to challenge provider broadband data or coverage maps and crowd-sourced data.

2.2 Emergency Broadband Benefit Program

Efforts to slow the spread of the coronavirus resulted in millions of Americans staying home and relying on broadband connections for telework, remote learning, shopping, and communicating with family and friends. The increased importance of broadband connectivity during the pandemic highlighted the pre-existing connectivity gap. For example, many students in low-income families currently lack adequate broadband at home which adversely affected their ability to complete schoolwork. A

⁷ The second order also adopted the Broadband DATA Act’s enforcement standard that is applicable to submissions of inaccurate or incomplete data, and it established standards for the treatment of confidential information that is received in the Fabric.

⁸ Generally, drive test data are mobile speed or performance tests performed in a moving vehicle such as a car. Tests taken on bicycles and motorcycles are considered tests from in-vehicle mobile environments, while tests taken at pedestrian walking speeds are considered tests taken in outdoor pedestrian environments. Stationary speed tests may also be taken.

Pew Research survey in April 2020 reported that 40% of low-income parents stated that it was likely or somewhat likely their child would need to use public Wi-Fi to complete their schoolwork due to the lack of a reliable broadband connection at home (Vogels et al., 2020).

For low-income families with access to broadband, cost can be a substantial challenge—particularly for those who suffered job loss or reduced income during the pandemic. In the same April 2020 survey, Pew Research found that approximately 28% of Americans with broadband at home “worry a lot or some about paying for this service... and 30% of smartphone owners say they worry at least some about paying their cellphone bill” (Vogels et al., 2020).

Congress, to provide aid, established a \$3.2 billion Emergency Broadband Connectivity Fund and directed the FCC to promulgate rules for the Emergency Broadband Benefit (EBB) Program to distribute these funds.⁹ Through the program, eligible low-income households can receive discounted broadband service and certain connected devices, and participating providers may receive reimbursement for these discounts. Eligible households may receive up to a \$50 per month discount on broadband service and associated equipment rentals, and households on Tribal lands may receive up to a \$75 per month discount. In addition, households may receive a one-time discount of up to \$100 for a laptop, tablet, or desktop computer with a co-payment of more than \$10 but less than \$50.

The EBB Program shares several similarities with the FCC’s Lifeline Program.¹⁰ Households who are eligible to participate in the Lifeline Program are also eligible to participate in the EBB Program, and they may receive discounts from both programs on the same or different services (FCC, 2021e).¹¹ Eligibility criteria for the EBB Program include the Lifeline qualifying conditions,¹² as well as participation in a free or reduced-price school lunch or breakfast program¹³; receipt of a Pell Grant in the current award year¹⁴; a substantial loss of income that places the household below the household income limit¹⁵; or meeting the criteria of a providers’ approved

⁹ The EBB Program will last until funds are exhausted or six months after the termination of public health emergency, whichever occurs later.

¹⁰ Established in the 1980s and codified in the 1996 Telecommunications Act, the Lifeline Program enables qualifying low-income households to receive monthly discounts of up to \$9.25 on voice or broadband internet access service, as well as on bundled voice and data services. Residents of Tribal lands may receive discounts of up to \$32.25 per month.

¹¹ In those cases when a household is eligible for both discounts for the same service, the Lifeline benefit is applied first, followed by the EBB Program benefit.

¹² Households may qualify for the Lifeline Program through participation in certain assistance programs, such as Medicaid or the Supplemental Nutrition Assistance Program (SNAP), or by having an income that is less than 135% of the Federal Poverty Guidelines.

¹³ Households may qualify using the student’s participation in either program, including through the USDA Community Eligibility Provision, during the 2019–2020 or 2020–2021 academic years.

¹⁴ Federal Pell Grants are offered to undergraduate students who demonstrate financial need.

¹⁵ This criterion requires that a qualifying household has experienced a substantial loss of income since February 29, 2020, due to job loss or furlough and has a total household income in 2020 that is less than \$99,000 for single filers and \$198,000 for joint filers.

existing low-income program (FCC, 2021e).¹⁶ Given the overlap between the programs and consistent with Congressional directives to use existing tools in support of the EBB Program, the FCC expanded and updated the Lifeline Program systems to establish the EBB Program expeditiously.¹⁷

The FCC adopted a report and order that sets forth the rules for the program on February 26, 2021 (FCC, 2021e). As of June 1, 2021, over 1000 providers had elected to participate in the EBB Program.¹⁸ Consumer enrollments for the EBB Program opened May 12, 2021 (FCC, 2021f), and over 1 million households enrolled in the first week (FCC, 2021g). As of October 3, 2021, over 6 million households had enrolled in the EBB Program,¹⁹ and that number continues to rise.

Broadband connections deliver economic benefits to both consumers and communities. From facilitating job searches to improving employee productivity for businesses, researchers have found that access to broadband improves economic outcomes (Tomer et al., 2020). The benefits that follow from universal broadband adoption depend on overcoming various impediments that face subscribers. In addition to ubiquitous deployment, a primary challenge to adoption is the cost of the service.²⁰ Both the EBB Program and Lifeline Program focus on the problem of affordability.²¹

For many program participants, the EBB Program offers the opportunity to initiate broadband service or upgrade to faster broadband speeds that lead to increased employment and productivity. One study estimated that “adding 10 Mbps to average download speeds in 2016 would have resulted in 139,400 additional jobs in 2019 (2% of total created jobs)” (Deloitte, 2021). In addition to improved economic outcomes, broadband access also enables remote learning and telehealth—both of which have positive social outcomes (Tomer et al., 2020).

2.3 Promoting Health During the COVID-19 Pandemic

In addition to providing emergency connectivity support for low-income Americans, the FCC acted to support health care connectivity—particularly telehealth—during the COVID-19 pandemic. Over the last year, the use of telehealth has exploded

¹⁶ Examples of such programs include Comcast Internet Essentials, Charter Spectrum Internet Assist, Cox Connect2Compete, Altice Internet Advantage, and Mediacom Connect2Compete.

¹⁷ Unlike the Lifeline Program, the EBB Program provides no support for voice service, and there are no minimum service standards for covered services. Although there are no minimum service standards for the EBB Program, the FCC finds that reimbursable service offerings should provide a broadband connection that is sufficient to support telework, telehealth, and remote learning.

¹⁸ For the current list of participating providers, see <https://www.fcc.gov/emergency-broadband-benefit-providers>.

¹⁹ For the latest program enrollment data, see <https://www.usac.org/about/emergency-broadband-benefit-program/emergency-broadband-benefit-program-enrollments-and-claims-tracker/>.

²⁰ Responses to a National Telecommunications and Information Administration (NTIA) survey that is administered every couple of years by the Census Bureau consistently shows that affordability is a major concern of consumers. See, e.g., the NTIA Internet Use Survey: <https://www.ntia.doc.gov/data/digital-nation-data-explorer#sel=tooExpensiveMainReason&disp=map>.

²¹ Other Universal Service Programs—such as the Connect America Fund—focus on the deployment of broadband to unserved and underserved areas.

and has become an increasingly vital tool for health care providers (FCC, 2021h). Telehealth technologies have the potential to improve health outcomes for patients and to reduce health care costs significantly (FCC, 2021h, p. 3). Since the start of the COVID-19 pandemic, the FCC has supported the availability and adoption of telehealth through several programs: the Rural Health Care (RHC) Program which is part of the USF; the COVID-19 Telehealth Program which is a Congressionally mandated program to distribute emergency funding for telehealth in response to the pandemic and the Connected Care Pilot Program which the FCC established to evaluate the long-term impact and effectiveness of USF support for telehealth.

The RHC Program. Established in 1997, the FCC's RHC Program consists of two components: (1) the Telecommunications Program which provides discounts on telecommunications services to ensure that rural health care providers pay no more than their urban counterparts; and (2) the Healthcare Connect Program which provides a 65% discount on the cost of broadband connectivity to eligible health care providers to encourage the formation of state and regional telehealth networks (FCC, 2020b, pp. 4–5).

At the onset of the pandemic, the FCC took a series of actions to mitigate the impact of the pandemic on rural health care providers. For example, it waived its gift rules to allow health care providers who participate in the RHC program to accept improved broadband connections or equipment for telehealth (FCC, 2020c). It also provided additional temporary relief to program participants, including extending the window for filing applications for funding; easing competitive bidding requirements; and extending certain expiring contracts and various administrative deadlines (FCC, 2020d).²²

COVID-19 Telehealth Program. Congress created the COVID-19 Telehealth Program in March 2020 pursuant to the CARES Act and, as was noted above, appropriated \$200 million to the FCC to support health care providers. On July 8, 2020, the FCC announced that it had awarded all \$200 million through 539 approved applications (FCC, 2020g).²³

In the Consolidated Appropriations Act, Congress appropriated a second round of \$249.95 million in funding for the COVID-19 Telehealth Program. The FCC issued an order that set out the application process and review criteria for Round 2 of the COVID-19 Telehealth Program (FCC, 2021h).²⁴ The order built on the successes

²² As the pandemic continued to surge throughout 2020 and into 2021, the FCC continued to extend relief for participating RHC program health care providers (FCC, 2020e; FCC, 2020f; FCC, 2021i).

²³ The awards helped to fund telehealth services and devices for 3,038 health care provider locations and over 4 million patients in 49 states plus the District of Columbia and Guam. The complete list of funded applications is available at <https://www.fcc.gov/sites/default/files/covid-19-telehealth-program-recipients.pdf>.

²⁴ It also released an order expanding the authority of the Universal Service Administrative Company (USAC) to include administration of the COVID-19 Telehealth Program and directed the USAC to administer the remainder of Round 1 and all of Round 2 of the program (FCC, 2021j). Remaining Round 1 administration includes, but is not limited to: conducting an initial review of invoices; providing outreach and guidance to stakeholders about the invoicing processes; and processing post-program feedback reports. For both the remainder of Round 1 and all of Round 2 of the Program, the FCC retained final funding decision-making authority.

and lessons that were learned from Round 1, while taking steps to improve the program in accordance with congressional guidance. With the help of FCC economists and data analysts, the FCC adopted a refined set of metrics for evaluating and prioritizing applications to ensure that funding is directed to the health care providers who are most in need (FCC, 2021h, pp 17–27). The application portal opened on April 30, 2021, and closed on May 6, 2021, and the FCC later granted an extension to certain applicants (FCC, 2021m).

Telehealth funding during the pandemic has enabled providers to protect and enhance safety for employees and patients, while continuing to provide essential healthcare. For example, Round 1 awardees used funds to transition their nonclinical workforce to remote settings, reduce in-person visits, and enable healthcare professionals who have been exposed to the virus to continue seeing patients while self-isolating.

Connected Care Pilot Program. The Connected Care Pilot Program is intended to examine how USF funding can promote the trend towards connected care services—particularly for low-income Americans and veterans (FCC, 2020b, p. 3). Using USF funding, the Connected Care Pilot Program will make available up to \$100 million over three years to help defray the costs of connected care services (FCC, 2020b). It will help health care providers improve health outcomes and reduce health care costs by providing funding for selected pilot projects. The program covers 85% of the eligible costs of broadband connectivity, network equipment, and information services that are necessary to provide connected care services (FCC, 2020b).

The Connected Care Pilot Program is structured to incentivize participation from a wide range of eligible health care providers, their patients, and a variety of broadband service providers. The application filing window for the Connected Care Pilot Program opened on November 6, 2020, and closed on December 7, 2020 (FCC, 2020h). On January 15, 2021, the FCC announced the initial round of Pilot Program awards (FCC, 2021k) and announced another set of projects on June 17, 2021 (FCC, 2021n). As of that date, the FCC had committed over \$57 million to 59 pilot projects that propose to serve patients across multiple treatment centers in 30 states and the District of Columbia (FCC, 2021n).

3 Auction Innovation at the FCC

As demand for electromagnetic spectrum usage rights continues to increase and wireless technologies continue to evolve, opportunities emerge for some frequencies to be used for purposes that are different from their current allocation. Consequently, the FCC faces the ongoing challenge of determining whether to share spectrum among different uses or to reallocate spectrum and offer redefined spectrum licenses for new uses, such as for 5G and other advanced services.

No single approach for repurposing and reassigning new licenses works for all spectrum bands. Each band faces different challenges due to its technical characteristics and historical incumbencies. For example, existing usage rights, incumbent license areas, potential interference issues between incumbents and new licenses, and the cost of relocating incumbents vary tremendously from band to band. As a

result, the FCC has had to adopt tailored repurposing and sharing approaches for each band, and has developed innovative auction formats to accommodate each novel repurposing approach.

Since the Broadcast Incentive Auction, several auction proceedings have presented repurposing challenges that were successfully addressed, at least in part, by modifications to a more traditional auction design.²⁵ FCC economists were actively involved in 2020 and 2021 in conducting or planning a number of auctions that addressed incumbent providers and repurposing challenges in creative ways.

At the same time, FCC economists have been engaged in developing and implementing reverse auctions to distribute USF support for mobile and broadband services to underserved areas. As with the spectrum auctions, the FCC has had to think creatively in order to adapt its approach to best meet its goals under the particular circumstances presented.

3.1 Spectrum Auctions

Auction 103: Spectrum Frontiers. The FCC released a Report and Order that adopted new band plans for the Upper 37 GHz, 39 GHz, and 47 GHz bands in late 2018 (FCC, 2018a). The FCC developed and implemented a novel approach to repurposing these high-frequency millimeter wave (mmW) spectrum bands which designated them for flexible use to enable 5G and other advanced wireless services (FCC, 2018a).

Much of the 39 GHz band was used primarily for point-to-point microwave service and was already licensed in overlapping and inconsistent geographic areas (Rectangular Service Areas (RSAs) instead of Partial Economic Areas (PEAs)) and for a frequency block size (50 megahertz) that did not coincide with the 100 megahertz blocks of the new band plan. To incentivize the incumbent licensees to relocate and/or relinquish their current licenses voluntarily—a statutory requirement for the FCC to use an “incentive auction” in which relinquishing incumbents are paid from auction proceeds—the FCC developed an incentive auction approach that involved only a single ascending bid auction.²⁶

As a preliminary step, incumbent licenses were reconfigured to correspond to shares of a new license in the PEA. The ratio of the MHz*pop covered by the existing license(s) relative to the MHz*pop covered by the new PEA license determined the dimensions of the modified license(s).²⁷

²⁵ Restructuring auctions were introduced at the FCC in a working paper that proposed two-sided “band restructuring” auctions of spectrum to deal with incumbent license holders (Kwerel and Williams, 2002).

²⁶ The auction served as both reverse and forward portions of the incentive auction by determining both the prices for and the winners of new licenses and the amounts of incentive payments that relinquishing incumbents would receive.

²⁷ Each incumbent’s modified holdings contained at most one partial PEA. To address concerns that the additional cost to convert a partial holding to a full new license in the auction could be considerable, incumbents could choose to move their partial modified license weighted MHz*pop to a different PEA, where the weights were an index of recent spectrum auction prices across PEAs to account for the different relative values of a MHz*pop across areas. For further details on the reconfiguration process, see FCC, (2019c).

To satisfy the requirement that the relinquishment of a license be “voluntary,” there was an Initial Commitment period, in which incumbents were given the options of retaining the modified licenses, and operating in the partial PEA geography at a repacked frequency after the auction, or relinquishing their usage rights in exchange for an “incentive payment” and the right to participate in the auction if they wished to consider retaining or expanding their holdings in the band based on auction prices. The value of an incentive payment would be equal to the incumbent’s share of a new license times the selling price of a new license in the auction.

The incumbent could choose to receive the payment in cash (acting strictly as a seller); or if it was a winning bidder in the auction, the incumbent could apply the value of the incentive payment to its winning bid obligations (thereby acting as seller and buyer).²⁸ By participating in the auction, an incumbent licensee could observe the price level and determine the point at which it wanted to drop out of the bidding and accept the incentive payment in cash in exchange for relinquishing its usage rights. In this way, this ascending bid auction and reconfiguration process presented incumbents with the same fundamental choice they would have faced had the incentive auction taken place as two separate auctions—a reverse auction to determine the prices at which incumbents would relinquish their usage rights and a forward auction for new licenses—as was done in the Broadcast Incentive Auction (Kwerel et al., 2017).

Auction 103 was conducted as a “clock auction,” a format in which prices tick upward in a series of bidding rounds during the “clock phase,” and bidders indicate the number of blocks they demand in categories of generic spectrum blocks.²⁹ Bidding rounds continue until the demand for blocks does not exceed the supply of blocks in any category. The clock phase of Auction 103 was followed by an “assignment phase” in which frequency-specific licenses were assigned to clock phase winners of the generic blocks. The auction closed in March 2020, with winning bids net of bidding credits totaling nearly \$7.6 billion and 28 bidders winning 14,142 licenses.³⁰ The incentive payments for existing licensees totaled almost \$3.1 billion, and the net proceeds for the auction were nearly \$4.5 billion.³¹

This reconfiguration and auction format succeeded in encouraging every incumbent licensee in the 39 GHz band to relinquish their modified licenses in exchange for an opportunity to receive an incentive payment, quickly clearing a path for the deployment of 5G and other advanced wireless services. This can be attributed to: (i) the auction design which, by allowing incumbent licensees to receive the price their spectrum usage rights command at auction, makes incumbent licensees face the true opportunity cost of retaining their licenses; (ii) the likelihood that the flexible use of the spectrum in the new band plan was more valuable than the use by

²⁸ For details on the initial commitment process and bidding procedures, see the webpage for Auction 103—especially the public notices that are listed under the “Major Releases” tab. Available at <https://www.fcc.gov/auction/103>.

²⁹ All generic blocks in a category are alike (area, requirements, etc.) except that they do not have a specified frequency.

³⁰ Available at <https://auctiondata.fcc.gov/public/projects/auction103>.

³¹ Available at <https://auctiondata.fcc.gov/public/projects/auction103>.

incumbents; and (iii) the coordination nature of an auction which puts all of the spectrum from a specific frequency on the market at the same time, thereby increasing the value to bidders who benefit from using spectrum in multiple areas. Thus, this auction allowed new users of the spectrum to compensate incumbent users fully for relinquishing their rights which resulted in an efficient repurposing of spectrum.

Auction 105: Auction of Priority Access Licenses. In the 3.5 GHz band, the FCC addressed the issue of accommodating incumbent federal users while opening the band up to non-federal uses by creating a non-exclusive use scheme. Under this unique scheme, Spectrum Access System (SAS) administrators will coordinate spectrum use among differing priority users and assign specific channels to users on a dynamic basis (FCC, 2018d). The highest priority users are incumbents, followed by Priority Access Licensees, and then General Authorized Access (GAA) users. Seven 10-megahertz priority access blocks (known as PALs)—which are licensed on a county-by-county basis, for a total of 22,631 licenses—were offered in Auction 105.³²

The auction commenced on July 23, 2020, and was conducted using a clock auction format to determine the winners of the seven PALs that were available in each county. Since specific frequencies would be determined dynamically by the SAS administrators, there was no need to hold a subsequent assignment phase to determine frequency-specific license rights.³³ Auction 105 saw robust participation, with many entities bidding for the first time in an FCC auction. Many of them were successful: 228 out of 271 bidders, the highest number of winning bidders ever in an FCC auction, won 20,625 of 22,631 PALs.³⁴

Auction 107: C Band. To make a portion of the 3.7–4.2 GHz band (C Band) available for 5G and other advanced services, the FCC faced yet another challenge in considering how to persuade the incumbent satellite licensees to relocate to the upper portion of the band (FCC, 2020k). Since incumbent satellite rights were non-exclusive, incumbents could not free up spectrum by making voluntary individual decisions, as was possible in the Broadcast Incentive Auction and the Auction 103 incentive auction.

In brief, the FCC set a five-year deadline for satellite providers to move all of their services to the 4.0 to 4.2 GHz frequencies. If the satellite providers met an accelerated relocation schedule by clearing the lower 100 MHz of spectrum in 46 of the top 50 PEAs within one year, and the full 300 MHz of spectrum within three years, then the satellite providers would receive an accelerated relocation payment. Winning bidders would be obligated to contribute prorated shares of the accelerated relocation payment amount plus other relocation costs in addition to making winning bid payments to the U.S. Treasury.

³² GAA users had access to the entire band from 3550 to 3650 MHz but were required not to cause harmful interference to incumbent users or PALs and to accept interference from these users.

³³ In contrast, Auction 107 offered larger licensing blocks, both in terms of bandwidth (20 MHz in Auction 107) as well as geography (PEAs).

³⁴ Available at <https://auctiondata.fcc.gov/public/projects/auction105>.

All of the satellite incumbents agreed to the accelerated relocation schedule. This condition was advantageous for two reasons. It would allow earlier access to some of the spectrum for new wireless licensees and it could provide relocation support to the satellite incumbents before the band was fully cleared.

Auction 107 commenced on December 5, 2020, and was conducted as an ascending clock auction with bidding for generic blocks in the clock phase and a subsequent assignment phase to assign the corresponding frequency-specific licenses (FCC, 2020i).³⁵ In the assignment phase, a winner of blocks that were not subject to early clearing was assigned contiguous final specific frequencies across the full 280 megahertz. A winner of blocks in an early-clearing category was assigned contiguous blocks within the lower 100 megahertz of the C Band for use during the interim period between the early and later clearing deadlines, and a contiguous final assignment of all of the blocks it won in the PEA (early-clearing and otherwise) within the full 280 megahertz band. This allowed for contiguous final assignments for all winning bidders of early-clearing blocks—albeit with the possibility that a bidder’s interim and final assignments might not be the same.

Auction 107, which closed on February 17, 2021, was the highest grossing FCC spectrum auction ever. It raised a total of over \$81.1 billion in net winning bids and nearly \$81.2 billion in gross winning bids, with 21 bidders winning a total of 5,684 licenses.³⁶ The three major nationwide service providers—AT&T, T-Mobile, and Verizon Wireless—together accounted for 85% of auction proceeds and won 90% of the licenses offered.³⁷ On July 23, 2021, 5676 licenses in the C band were granted (FCC, 2021o).³⁸ Acting Chairwoman Jessica Rosenworcel stated that “With these licenses in hand, more carriers can deploy mid-band 5G, which means faster speeds over much wider coverage areas and more robust competition” (FCC, 2021o).

Auction 108: Auction of overlay licenses. The FCC is also taking steps to repurpose the 2.5 GHz band to make more mid-band spectrum available for advanced 5G wireless services. The 2.5 GHz band is currently allocated to the Educational Broadband Service (EBS) and the Broadband Radio Service (BRS), but a portion of the

³⁵ In the clock phase, Auction 107 included two categories of generic blocks in the 46 PEAs that had blocks that were subject to the earlier clearing deadline (five early-clearing blocks in the 3.7 to 3.8 GHz band in one category and nine blocks in the 3.8 to 3.98 GHz band in the other category). In the remaining 360 PEAs, there was a single category of 14 generic blocks. For details about the auction format, see the public notices that were released prior to the start of the bidding, available under the “Releases” tab of the Auction 107 webpage, available at <https://www.fcc.gov/auction/107/releases>.

³⁶ Available at <https://auctiondata.fcc.gov/public/projects/auction107>.

³⁷ Available at https://auctiondata.fcc.gov/public/projects/auction107/reports/assignment_bidder_status.

³⁸ Two petitions to deny were filed by DISH Network Corporation (DISH) which requested that the Commission deny or designate for hearing the long-form applications of Cellco Partnership (Verizon Wireless) and T-Mobile License LLC (T-Mobile). Petition to Deny of DISH Network Corporation, AU Docket No. 20–25, ULS File No. 0009446983 (filed Apr. 12, 2021); Petition to Deny of DISH Network Corporation, AU Docket No. 20–25, ULS File No. 0009446137 (filed Apr. 12, 2021). The FCC’s Wireless Telecommunications Bureau (WTB) and Office of Economics & Analytics (OEA) released an order that denied DISH’s petitions and indicated that the long-form applications of Cellco and T-Mobile would be processed consistent with the Order and the Commission’s rules. *T-Mobile License LLC; Cellco Partnership; Applications for 3.7–3.98 GHz Band Licenses, Auction No. 107*, Memorandum Opinion and Order, DA 21–891, at 16 (WTB & OEA July 23, 2021).

band is not assigned. The FCC adopted new rules in 2019 that allowed more flexible uses of the band, including for current licensees, and it created a Rural Tribal Priority window to make new licenses available to rural Tribal Nations prior to the auction (FCC, 2019b). The remaining white space will be auctioned; but in contrast to the other repurposing auctions that offered effectively cleared (or to-be cleared, as in Auction 107) spectrum, the auction of the 2.5 GHz band (Auction 108) will offer county-based overlay licenses with geographic and spectral exclusions to protect existing licenses.

As a result of the varying geographic and spectral incumbencies, licenses cannot be grouped into categories of sufficiently similar blocks, and so a clock auction of generic licensing blocks is not viable. Earlier this year, the FCC sought comment on two potential auction formats: a single-round auction with limited package bidding and a simultaneous multiple-round auction (FCC, 2021).

3.2 Reverse Auctions for Universal Service

In 2011, the FCC created the Connect America Fund (CAF) to reform and ultimately replace all existing high-cost support mechanisms (FCC, 2011). The Connect America Fund was highly innovative: It would rely on “incentive-based, market-driven policies, including competitive bidding, to distribute universal service funds as efficiently and effectively as possible.” (FCC, 2011). Implementing this significant policy shift, the FCC conducted reverse auctions to award universal service support and adopted a peer-reviewed cost model that estimated the cost to bring fixed broadband to unserved areas. In 2012, the FCC conducted the Mobility Fund Phase I auction (Auction 901) which awarded close to \$300 million in one-time support to bring mobile broadband to unserved areas.³⁹

This auction was followed in 2014 by the Tribal Mobility Fund Phase I auction (Auction 902), which awarded close to \$50 million to bring mobile broadband to unserved Tribal areas.⁴⁰ In 2014, the FCC completed the development of and adopted the Connect America Cost Model (CACM) which “estimate[d] the cost to provide voice and broadband-capable network connections to all locations in the country.” (FCC, 2011; FCC, 2013; FCC, 2014). After offering model-based support to price cap providers in 2015 (FCC, 2015),⁴¹ the FCC conducted the CAF Phase II auction (Auction 903) in 2018, which awarded almost \$1.5 billion to bring fixed broadband to some of the most difficult to serve areas in the country.⁴²

³⁹ See, generally, Auction 901: Mobility Fund Phase I, available at <https://www.fcc.gov/auction/901>. Auction 901 awarded support based upon road miles served.

⁴⁰ See, generally, Auction 902: Tribal Mobility Fund Phase I, available at <https://www.fcc.gov/auction/902>. Auction 902 awarded support based upon population served.

⁴¹ Price cap carriers receive universal service fund support via price cap regulation as compared to rate of return regulation. Price cap carriers tend to be larger incumbents—“Bell Operating Companies and other large and mid-sized carriers.” (FCC, 2011).

⁴² See, generally, Connect America Fund Phase II Auction (Auction 903), available at <https://www.fcc.gov/auction/903>. Auction 903 awarded support based upon aggregations of cost model estimates for locations in unserved census blocks, rolled up to census block groups for the purposes of bidding in the auction.

RDOF Phase I Auction (Auction 904) Results: In January 2020, the FCC adopted the policy framework for the next phase of implementing the Connect America Fund by establishing the Rural Digital Opportunity Fund (RDOF) (FCC, 2020l). The RDOF Phase I auction (Auction 904) was a descending clock auction that was designed to encourage competition. Eligibility for the auction was technologically neutral: Companies could choose to deploy any broadband technology if they were otherwise qualified; and both established and new providers—including relatively new entrants to the broadband marketplace such as rural electric co-operatives—were allowed to bid for support to bring broadband to unserved areas (FCC, 2020l).

To focus funding on areas that needed more support, the location cost thresholds were modified for Tribal areas and for areas that still lack 10/1 Mbps broadband (FCC, 2020l). These modifications effectively increased the number of such locations that were eligible for support in the auction and increased the maximum amount of funding that was available for these locations. Additionally, the auction design relied upon a weighting system that favored higher speed, lower latency services, and included a preferential assignment mechanism that assigned areas during the clearing round to the bids for the highest speed and lowest latency services under certain conditions (FCC, 2020l).

After conducting a limited challenge process, the FCC finalized the eligible areas which were census block group aggregations of the unserved census blocks in that group (FCC, 2020m). The reserve, or starting, price for each biddable unit in the auction was the sum of the cost model estimates for the locations in the unserved blocks in each census block group. The estimated cost to serve all eligible areas was approximately \$26 billion and the budget was \$16 billion.⁴³

Not surprisingly, the auction drew significant interest, with 505 companies applying to participate in the auction (FCC, 2020n). In October 2020, the FCC announced that 386 companies had qualified to participate in the auction, including some consortia that were composed of dozens of smaller companies (FCC, 2020o). The auction, which commenced on October 29, 2020 and concluded on November 25, 2020, awarded \$9.2 billion to 180 winning bidders to bring broadband to approximately 5.2 million locations across the country (FCC, 2020p). Almost 99% of eligible locations were awarded support, with 99.7% of the locations' receiving winning bids to bring service of at least 100 Mbps download speed and 85% of locations receiving bids to provide Gigabit speed service (FCC, 2020p).

After a process in which winning bidders could divide their bids among companies that had joined together to bid in the auction—as a consortium or otherwise—417 companies submitted long-form applications to receive support. In July 2021, the FCC announced that it was ready to authorize over \$311 million in funding across 36 states for 48 broadband providers to bring 1 Gbps broadband speeds to nearly 200,000 homes and businesses over the next 10 years (FCC, 2021p). The

⁴³ The starting price for each census block group (the minimum bidding unit in the auction) was the aggregate of the Connect America Cost Model estimate to deploy broadband in the eligible census blocks in that census block group. The total estimated cost to deploy broadband to all the eligible census blocks in these census block groups was \$26 billion.

FCC continues to review the remaining long-form applications to determine whether they meet all legal, financial, and technical requirements, and will announce on a rolling basis when it is ready to authorize additional funding.

4 Communications Marketplace Report

In December 2020, the FCC published the second *Communications Marketplace Report* (2020 CMR), in accordance with a provision of the RAY BAUM'S Act of 2018 (U.S. Congress, 2018) that required that the FCC provide a comprehensive evaluation of the state of the U.S. communications marketplace (FCC, 2020j).⁴⁴ A primary objective of the report is to assess the state of competition⁴⁵ including, for example, an evaluation of the extent of entry barriers for entrepreneurs and other small businesses, and the current state of network deployment.

Competition was assessed across the communications marketplace by reporting data for an extensive list of quantitative metrics. This multi-dimensional approach acknowledges that no single measure definitively captures the intensity of competition in a market.⁴⁶ Some of the metrics examined can be viewed as “inputs” into the competitive process, such as the number and size distribution of service providers and their ownership of critical factors of production such as radio spectrum licenses. Other metrics measure “outcomes,” including: the price level (adjusted for service quality); the scope of service coverage (meeting certain minimum quality thresholds); and the pace of product innovation.

As required by the RAY BAUM'S Act, the 2020 CMR assesses the state of competition across the communications marketplace, including: fixed and mobile data service; voice telephony; broadcast, multichannel, and online video; and terrestrial and satellite radio. In most cases, the 2020 CMR presented competitive metrics over time, with special attention to updating the time series that were reported in the 2018 CMR. When location information was available, the 2020 CMR frequently compared metrics across geographic areas. For instance, the FCC has a particular

⁴⁴ Repack Airwaves Yielding Better Access for Users of Modern Services Act of 2018 (RAY BAUM'S Act), Pub. L. No. 115–141, 132 Stat. 1087 (codified at 47 U.S.C. Sect. 163). Section 401 of the Act requires the FCC to publish a report on the state of the communications marketplace in the last quarter of every even-numbered year.

⁴⁵ The Report should “assess the state of competition in the communications marketplace, including competition to deliver voice, video, audio, and data services among providers of telecommunications, providers of commercial mobile service (as defined in Sect. 332), multichannel video programming distributors (as defined in Sect. 602), broadcast stations, providers of satellite communications, Internet service providers, and other providers of communications services.” Ibid., Sect. 401(b)(1).

⁴⁶ As competition is multi-dimensional, one should not expect that any two of the various competitive metrics will convey the same message with regard to the intensity of competition. It is possible, for example, to have average monthly subscription prices increase despite greater competition if the quality of the service also increases significantly: *e.g.*, faster speeds or greater capacity which result in lower *quality-adjusted* prices. We do find, however, that in many cases the competitive indicators point in the same direction.

interest in comparing the status of the communications services between urban and rural regions of the United States.

In addition, the 2020 CMR compares pricing, quality, and deployment of fixed and mobile broadband services in the United States with over two dozen OECD countries (FCC, 2020i, Appendix G). Further, the 2020 CMR notes that cross-service entry in which providers of one type of service repurpose their facilities to provide another type of service has been a significant source of competition in recent years.⁴⁷

4.1 Mobile Wireless Market

Mobile wireless services continue to play a critical role in Americans' daily lives—a role that was heightened by the COVID-19 pandemic.⁴⁸ Wireless providers seek to meet consumer demands by investing in their networks and the advanced capabilities that those networks make possible,⁴⁹ while the FCC continues to make spectrum available to help meet the increasing demand for wireless services (FCC, 2020j, pp. 20–21).

The 2020 CMR reports that the number of mobile wireless connections has continued to increase (FCC, 2020j, pp.12–13), and consumers increasingly use their mobile devices to access data services, compared to voice and text services (FCC, 2020j, p. 19, Figure II.A.9). In the middle of 2018, the product category “Internet Connected Devices” surpassed “Prepaid Connections,” becoming the second-largest segment by volume and accounting for approximately 22% of all wireless connections (FCC, 2020j, p. 13).⁵⁰ Overall, monthly data usage per smartphone subscriber increased approximately 39% from year-end 2018 to year-end 2019, reaching an average of 9.2 GB per subscriber per month (FCC, 2020j, pp. 18–19).

Along with the increase in data usage, wireless speeds have been increasing. This can be seen in Fig. 1 which presents the nationwide mean and median 4G LTE download speeds over 2014–2019 using the Ookla Net Index (crowdsourced) data,⁵¹ and indicates that median download speeds were 26.2 Mbps in the second half of 2019—an increase of approximately 138% from 11.0 Mbps in the first half of 2014 (FCC, 2020j, pp. 43–45). Increases in download speeds and 4G LTE network

⁴⁷ See RAY BAUM'S Act, 401(d)(1) which instructs the FCC to include “intermodal competition” in its assessment.

⁴⁸ For cross-country evidence of mobile data usage during the pandemic, see Rizzato and Fogg, (2021).

⁴⁹ In the last few years, all four (now three) nationwide providers have invested a higher percentage of their revenues into their respective networks in preparation for 5G (FCC, 2020j, p. 37). This includes increased deployment of small cells and Distributed Antenna Systems (DAS) to fill local coverage gaps, densify networks, and increase local capacity. CTIA ,(2020) estimates that 80% of future deployments of wireless infrastructure will be in the form of small cells (FCC, 2020j, pp. 26–27).

⁵⁰ In contrast to postpaid services in which subscribers are billed monthly after services are provided, “Prepaid Connections” are customers who pay for services in advance of receiving them. “Internet Connected Devices” are data-capable devices, with web-capable devices, smartphones, tablets/laptops and wireless broadband modems composing the vast majority of all wireless-connected devices.

⁵¹ Ookla gathers crowdsourced mobile speed data from smartphone users who install its Speedtest mobile app. That app is available at: <https://www.speedtest.net/apps/mobile>.

capacities allowed consumers to use their mobile devices in new ways, such as: streaming video in high definition; accessing ride-sharing platforms; and live-mapping driving routes (FCC, 2020j, p. 38).⁵²

The 2020 CMR also notes that the average revenue per GB of wireless services has been declining. Figure 2 presents four different estimates of the average revenue per GB based on data from CTIA (2020) and the U.S. Census Bureau. As of year-end 2019, the average revenue per GB decreased by approximately 20% to 30% compared to 2018 levels (FCC, 2020j, p. 36, Figure II.A.25).

4.2 Fixed Broadband Market

The 2020 CMR assessed non-price competition in fixed broadband service quality including the actual speed of service experienced by consumers. As of December 2019, approximately 63% of the 105 million residential connections had advertised download speeds of at least 100 Mbps—more than five times the number of connections capable of at least 100 Mbps in June 2015. At the same time, the number of connections with download speeds below 100 Mbps declined year over year (FCC, 2020j, p. 83). Figure 3 depicts the change of fixed broadband connection speeds over time.

The FCC's 2020 Urban Rate Survey reports the following weighted means for prices of Internet-only packages: \$60.30 per month for DSL; \$80.67 per month for cable; \$86.48 per month for fixed wireless; and \$102.63 per month for fiber (FCC, 2020j, p. 76).

In terms of fixed broadband availability, the percentage of the population that is not covered by any fixed broadband service provider or that has only one provider has declined, and more users have choices among two or more providers. For instance, population with multiple options of service providers for 25/3 Mbps services increased to 73.8% in 2019 from 58.8% in 2016.⁵³ The 2020 CMR reports that the number of provider options increased with the number of households in the census block group, the population density, and the median household income (FCC, 2020j, p. 89).

The FCC also assesses and monitors the deployment of advanced telecommunications capability (ATC) as required by the RAY BAUM'S Act of 2018 (FCC, 2020j, p. 156 l). At the time of the release of the 2020 CMR, the FCC's fixed-speed benchmark for ATC was 25/3 Mbps (FCC, 2020j). Specifically, the 2020 CMR provides deployment estimates for fixed and mobile terrestrial broadband coverage by download/upload speed tiers based on year-end 2019 FCC Form 477 data submitted by broadband providers (FCC, 2020j, pp. 156–157).⁵⁴

⁵² Letter from Kara Graves, Assistant Vice President, Regulatory Affairs, CTIA, to Marlene Dortch, Secretary, FCC, OEA Docket No. 20–60, WTB Docket No. 19–348, Attach., The 4G Decade: Quantifying the Benefits at 10 (filed Aug. 6, 2020).

⁵³ Staff calculations based on FCC, (2018b, p. 98, Fig. D-4) and FCC, (2020j, p. 87, Fig.II.B.23).

⁵⁴ As the FCC has repeatedly stated, having accurate and reliable broadband data is critical, and questions have arisen in various contexts with regard to the accuracy of coverage that is reported by the FCC

Over the 2015–2019 period, coverage of ATC continued to expand, although the patterns of deployment varied by region and by technology. For example, based on 2019 FCC Form 477 data, approximately 17% of Americans in rural areas and 21% of Americans in Tribal lands lacked coverage from fixed terrestrial 25/3 Mbps broadband, compared to only 1% of Americans in urban areas (FCC, 2020j, p. 160, Fig. III.A.1).⁵⁵

4.3 International Broadband Data Comparison

As part of its statutory requirement, the FCC also must include information on broadband service capability in 75 communities in at least 25 countries abroad that are geographically diverse and comparable to various communities in the United States with respect to population size, population density, topography, and demographic profile.⁵⁶ The main speed and performance analysis relied on Ookla Speed Test data (FCC, 2020i, Appendix G, pp. 4–6). U.S. mean download speed rankings improved significantly for both fixed and mobile broadband in recent years.

The U.S. fixed broadband download speed rankings improved to 5th (out of 36 countries) in 2019 from 14th (out of 35 countries) in 2015; similarly, the U.S. mean mobile 4G LTE broadband download speeds also improved to a ranking of 25th in 2019 from a ranking of 35th in 2016. Meanwhile, the U.S. mean upload speed and latency rankings have remained relatively stable since 2015.⁵⁷ The 2020 CMR also included 5G availability and download speeds by country using OpenSignal crowd-sourced mobile speed data (FCC, 2020j, Appendix G, p. 36)—although the sparse 5G availability in a limited number of countries prevents us from making meaningful comparisons across countries.

Comparing broadband prices across countries presents several challenges, including: (1) complex broadband product offerings that vary in speeds, types of technologies, data limits, contractual conditions, additional services included, and consequences of exceeding usage limits; (2) discounted service bundles that include broadband with other services; and (3) differences across countries in the quality of networks deployed, cost factors (*e.g.*, population density and topography), and demand factors (*e.g.*, demographics and content quality) that may affect pricing.

Footnote 54 (continued)

Form 477 deployment data. To improve the data, the FCC is implementing a new data collection (FCC, 2020j, pp. 49–50). See Sect. 2.1 above (discussing collecting improved coverage maps).

⁵⁵ For purposes of the analysis of access to advanced telecommunications capability in the 2018 CMR and the 2020 CMR, a census block is classified as served if the FCC Form 477 data indicate that service is available in the census block, even if not to every location. Therefore, it is not necessarily the case that every household, housing unit, or person will have coverage from a given service provider in a census block that this analysis indicates is served.

⁵⁶ 47 U.S.C. Sect. 1303(b)(1).

⁵⁷ The mean U.S. fixed broadband upload speed ranks 17th of the 36 comparison countries in 2019 compared to 18th (of 35 countries) in 2015. The mean U.S. mobile 4G LTE broadband rankings have stayed at 35th place between 2015 and 2019. For latency rankings, the United States ranks consistently in 24th place for fixed broadband and 34th place for mobile 4G LTE broadband during the 2015–2019 period (FCC, 2020j, Appendix G, pp. 9–10, 22–23).

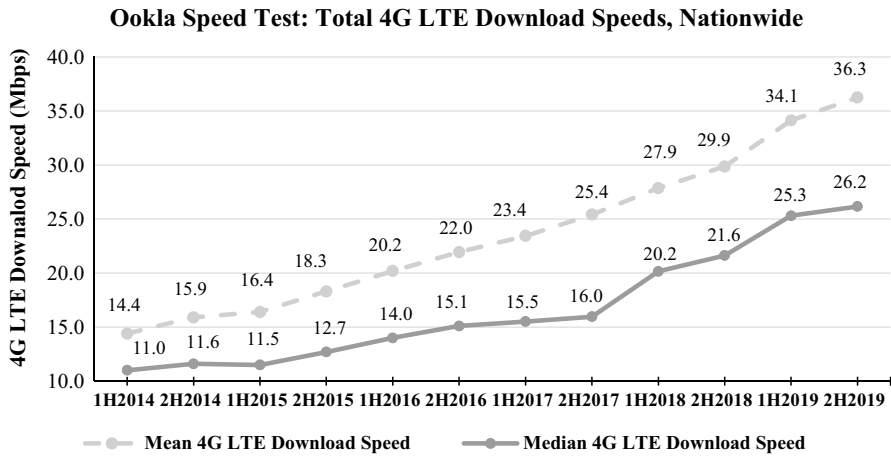


Fig. 1 The data are sourced from the Ookla SPEEDTEST data, © Ookla, LLC. All rights reserved. Published with permission of Ookla

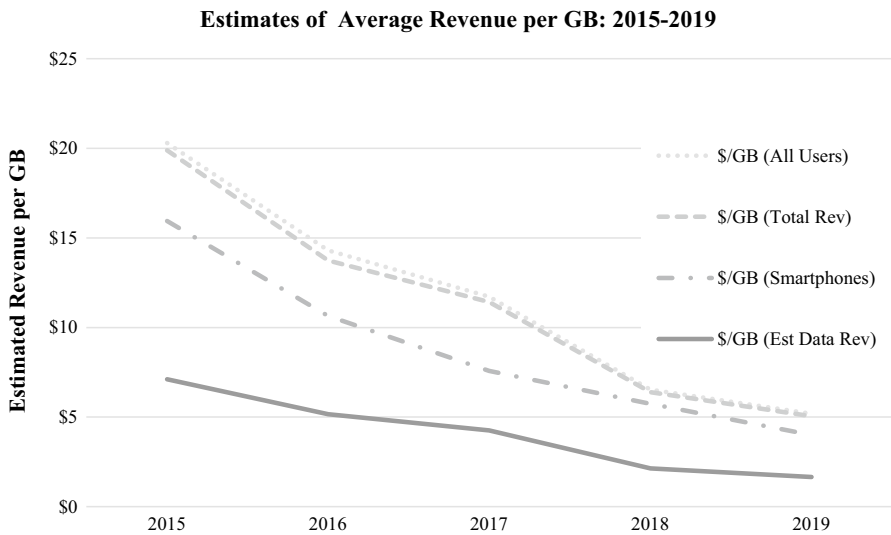


Fig. 2 The data are sourced from CTIA, (2020) and the U.S. Census Bureau Service Annual Survey available at: <https://www.census.gov/programs-surveys/sas.html>

The report compared broadband prices using two methods: (1) a broadband price index and (2) a hedonic price index.⁵⁸ The broadband price index ranks countries by their weighted average price, while the hedonic price index accounts for quality differences as well as market-level cost and demographic differences—such as

⁵⁸ See FCC, (2020j), Appendix G, pp. 54–85) for technical details of the hedonic model.

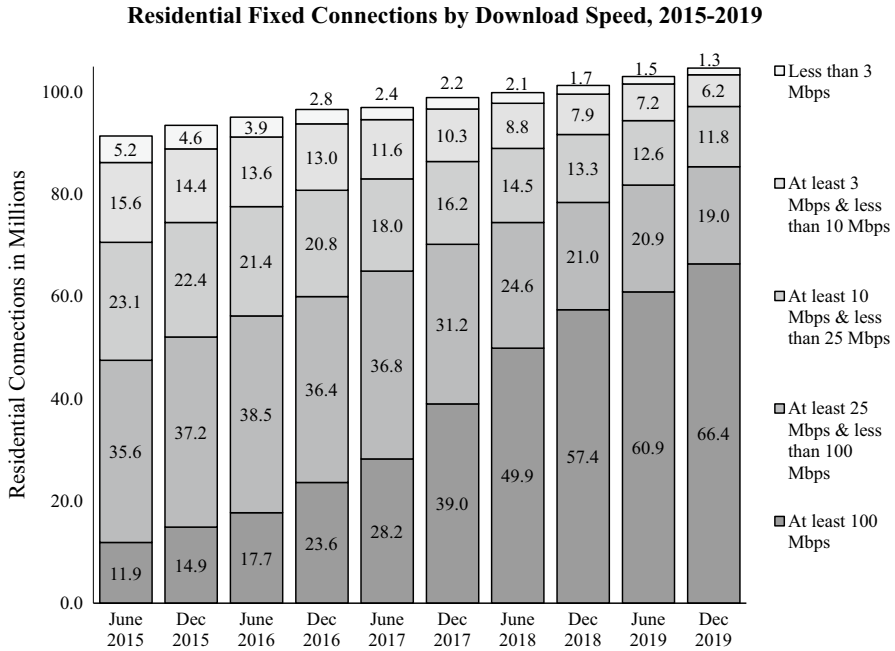


Fig. 3 Staff calculations based on FCC Form 477 data

population density, income, terrain ruggedness, and education levels—that are likely to affect pricing across countries.

The 2020 CMR ranks the countries from the least expensive (1st) to most expensive (26th) based on the two price indexes. Based on the broadband price index approach, the United States ranked 21st for both fixed and mobile broadband prices in 2020. In contrast, using the hedonic price index approach, the United States ranked the 2nd least expensive country for fixed broadband prices and the 7th least expensive country for mobile broadband prices among the 26 comparison countries.

4.4 Video Market

Traditionally, consumers received their video entertainment from broadcast television stations or from multichannel video programming distributors (MVPDs) that include cable TV and direct broadcast satellite (DBS) services. That changed significantly about 10 years ago when consumers began to rely more on online distribution of video. Year after year, online video distributors (OVDs) claim an increasing share of U.S. viewership.⁵⁹ The pandemic increased the demand for video streaming and imposed further stress on telecommunications networks.

⁵⁹ Examples of OVDs include Netflix, Hulu, Amazon Prime Video, YouTube TV, Disney +, AT&T TV Now, and Sling TV.

In response to the surge in video streaming in Europe, for example, regulators asked the major providers to temporarily scale back their bitrates delivered to their European customers to reduce network load (Chee, 2020). No similar action was necessary in the United States to meet consumer demands.

Broadcast television stations offer linear video programming channels over the air and through MVPDs and OVD partners to households. In 2019, stations generated nearly two-thirds of their revenue from the sale of advertisements during the programming and one-third from fees that were paid by MVPDs and OVDs for the carriage of the station's signal (FCC, 2020j, pp. 131–132). MVPDs use wireline or satellite technologies to deliver video programming in channel packages.⁶⁰ Continuing a downward trend that began in 2013, MVPDs lost 6.4 million video subscribers between 2018 and 2019—an accelerating loss compared to the decrease of 3.6 million subscribers between 2016 and 2017 (FCC, 2020j, pp. 103–104; FCC, 2018b, p. 41).

OVDs—which deliver video content to consumers via the Internet—continued to proliferate in the two years leading up to the release of the 2020 CMR. OVDs use a variety of business models, including: advertising-supported video offerings; a subscription model for access to an entire video library; and/or a transactional approach where consumers pay to view a specific movie or television episode on a per-program basis. Most notably, the number of subscription-based OVDs had risen in recent years—with a rapid growth rate of over 34% between 2018 and 2019—garnering a growing share of viewers at the expense of traditional MVPDs (FCC, 2020j, p. 123, Fig. II.D.9).

5 Office of Economics & Analytics (OEA) Economic Research

The FCC encourages staff economists to propose and conduct research into questions that are relevant to telecommunications policy and to publish their findings in a working paper series to stimulate discussion and critical feedback inside and outside the agency. One of the most influential FCC working papers, for example, made the early economic case for auctioning radio spectrum licenses many years before the FCC's first spectrum auctions (Kwerel & Felker, 1985). Still other working papers have been inspired by current policy-making initiatives, and in some cases, the FCC has relied upon their findings in support of a rulemaking.⁶¹ In the past year, the FCC released three new working papers that we briefly describe in this section.

⁶⁰ Traditional MVPDs include cable providers (*e.g.*, Comcast and Charter), telephone company providers (*e.g.*, Verizon Fios and AT&T U-verse), and direct broadcast satellite providers (*e.g.*, DISH and DIRECTV).

⁶¹ For example, DeGraba, (2000) proposed a bill-and-keep methodology for intercarrier compensation that led the FCC to adopt a bill-and-keep approach to intercarrier compensation reform. Available at <https://www.fcc.gov/document/fcc-releases-connect-america-fund-order-reforms-usfcc-broadband>. More recently, a 2019 rulemaking with regard to broadband access to multi-tenant buildings cited Carare and Kauffman, (2019) that found that mandatory access laws are associated with higher rates of broadband adoption among non-MTE residents. Available at <https://docs.fcc.gov/public/attachments/FCC-19-65A1.pdf>.

5.1 Impact of Broadband Penetration on U.S. Farm Productivity

Over the years, the FCC has implemented several universal service programs to connect Americans living in rural areas—some of which are discussed above. More recent initiatives have specifically targeted agricultural areas to promote the productivity benefits of high-speed internet. For example, Congress directed the FCC to create a “Precision Agriculture Task Force” in consultation with the Department of Agriculture.⁶² A maintained hypothesis that underpins these programs is that greater access to and use of communications technologies will pay dividends in terms of improved agricultural productivity.

LoPiccalo, (2020) addressed the question of whether adoption of broadband internet access in agricultural-intensive communities has resulted in higher crop yields or lower costs of production. LoPiccalo, (2020) began by constructing a panel dataset of broadband penetration rates and agricultural outcomes that cover the entire nation. The panel was anchored in the U.S. Department of Agriculture’s quinquennial “Census of Agriculture.”⁶³ This comprehensive census of the agricultural sector—dating back to 1840—includes yields for five row crops (corn, cotton, hay, soybeans, wheat) and five farm-wide expense categories (operating, chemical, fertilizer, fuel, seed/plants).

The agricultural census data were merged with the FCC’s non-public Form 477 data on the number of subscriptions to internet access services that are provided over fixed lines, fixed wireless, and satellite but excluding mobile wireless. Subscriptions are further classified by two minimum download/upload speed thresholds: 10/0.768 Mbps and 25/3 Mbps. While subscription data are available by census tract, they were aggregated to the county level to conform to the USDA data. Three vintages of the semi-annual Form 477 data (December 2008, June 2012, June 2017) were matched with three waves of the agricultural census (2007, 2012, 2017). Standard demographic information—*e.g.*, education, income—at the county level was merged with the panel.

LoPiccalo, (2020) estimated a reduced-form model of crop yields (bushels/bales per harvested acre) on broadband penetration rates and various controls. Among the controls were average acreage and employment per farm in each county to account for scale effects. County and year fixed effects were included to capture geographic and temporal factors that otherwise may be correlated with the error term. The fixed effects regressions showed that crop yields were greater in counties with higher internet penetration rates at both speed thresholds, but treatment effects were consistently larger for the faster subscriptions than those for the slower connections—which suggests that speed matters for crop production.

⁶² Congress directed the FCC, in consultation with the Secretary of Agriculture, to establish the Precision Agriculture Connectivity Task Force in the Agricultural Improvement Act of 2018 (the 2018 Farm Bill).

⁶³ USDA’s National Agricultural Statistics Service (NASS) collects survey responses from all U.S farms and ranches in years ending in 2 and 7. See <https://www.nass.usda.gov/AgCensus/>.

Concerned about the potential endogeneity of broadband subscription data, LoPiccolo, (2020) addressed potential bias by including Hausman-style instruments that are based on the broadband penetration rates of neighboring communities. Instrumental variable estimates were consistently larger than the ordinary fixed-effects regression results which suggests potential downward bias when no account is taken of endogeneity. Standard tests of weak instruments were consistently rejected. In specific terms, the regression results showed that, for example, a doubling of the take-up of 25/3 Mbps connections was associated with 3.6% *higher* corn yields.

LoPiccolo, (2020) also estimated reduced-form regressions of farm expenses on broadband penetration rates and the same set of control variables as with the crop yields regressions. Expense levels did not show strong relationships with penetration rates; the broadband coefficient was negative for most row crops, but it was often not statistically significant. Again, to be specific, the results showed that, for example, a doubling of the 10/0.768 Mbps subscription rates was associated with a 2.4% *reduction* in operating expenses per farm operation.

This working paper is among the first empirical investigations of the relationship between broadband adoption and emerging applications of communications technology to agricultural production. There was scant academic research to draw on despite the widespread belief that internet access enabled farmers and ranchers to be more efficient. The paper can inform FCC policy that affects the deployment, adoption, and usage of broadband internet in areas with widespread agricultural production.

5.2 The Digital Divide in U.S. Mobile Technology and Speeds

Dempsey and Sun, (2020) focus on inequalities in access to high-speed wireless broadband. High-speed Internet access is critical to economic opportunity, job creation, education, and civic engagement, and yet, not all Americans have access to high-speed Internet/advanced telecommunications. While there is an extensive literature on the gap in access to fixed broadband networks, access to mobile broadband has not been studied with the same level of intensity. Dempsey and Sun, (2020) explore inequality in access to mobile broadband services: they focus on the quality of service that is experienced by different demographic groups.

Specifically, the paper asks the following two research questions: First, is there a digital divide in how certain groups access mobile broadband as measured by the mobile connection technology? Second, is there a digital divide in the quality of mobile broadband as measured by download and upload speeds?

To investigate the first question, the authors estimated a multinomial logit model of the consumer use of the type of on-air connection (WiFi versus 3G, Non-LTE 4G, or LTE) on U.S. county demographics and characteristics, as well as technological variables. To investigate the second question, the authors ran separate ordinary least squares (OLS) regressions of log download and upload speeds for each technology on U.S. county demographics and characteristics, and technological variables.

Connection technology and speed data were obtained from the Ookla Speedtest app for the last six months of 2016. The county in which each test took place was

identified by mapping the latitude and longitude of the test. The location information allowed each test to be matched to county-level data from the 2015 five-year American Community Survey (ACS) in order to provide local demographic information and other county characteristics. In addition, the regressions accounted for factors such as terrain, variation across states, time of day, and number of competitors.

Among other findings, Dempsey and Sun, (2020) concluded that the more “rural” was a county—counties with lower population density—the less likely were tests in that county to occur over WiFi as compared to one of the three mobile technology categories. A lower population density in a county was also associated with slower speeds on tests that were taken over all technologies. Further, both higher minority population and older population of the county were associated with higher rates of tests on 3G and non-LTE 4G rather than LTE or WiFi, as well as slower speeds over advanced technologies.

The paper provides an important snapshot of the state of the digital divide in mobile broadband. It supplements existing studies that have exclusively focused on access to fixed broadband. Ultimately, this research and future extensions can help the FCC better determine how to ensure all Americans have access to high-speed broadband service.

5.3 Market Size and Local Television News

Makuch and Levy, (2021) examine the relationship between the number of independent local TV news operations in a market and market size. The FCC regulates local TV station ownership to advance three policy goals: competition; viewpoint diversity; and localism (FCC, 2018c). Makuch and Levy, (2021) suggest that a TV station merger that would eliminate an independent source of local news may present a tradeoff between viewpoint diversity and localism. Allowing a merger eliminates an independent outlet and thereby reduces viewpoint diversity, but the merged entity may now have the resources to preserve or even increase the quantity and quality of local news that is available in the market, which thereby could maintain or improve localism. By estimating the relationship between market size and local TV news operations, the analysis can help assess whether a market is likely to sustain the current number of local news operations or whether a proposed merger may only speed up an inevitable loss of viewpoint diversity while increasing or preserving localism.

For the analysis, Makuch and Levy, (2021) compiled the number of independent local TV news operations in each market as of July 2019. Two stations that produced local news were considered independent if they had different owners, did not have a service sharing agreement, and did not share a news director. Market size was measured by the number of TV households in the market. Makuch and Levy, (2021) estimated an ordered logit model with four ordered categories of the outcome variable—local news operations—and with the number of TV households and additional market characteristics as explanatory variables.

The results show a strong positive relationship between market size and the number of independent local TV news operations, with diminishing returns to market

size. Using the estimated coefficients, Makuch and Levy, (2021) determined market size thresholds above which a market is predicted to sustain two, three, or four or more local TV news operations. These thresholds can be used to assess proposed mergers that would eliminate an independent local TV news operation.

6 Conclusion

As explained in this essay, over the past year FCC economists helped in initiatives that were aimed at closing the connectivity gap—which were especially vital in light of the COVID-19 pandemic. In addition, FCC economists contributed to the FCC’s extensive response to COVID-19. Further, FCC economists contributed to various spectrum auctions and evaluated competition in the communications marketplace as reflected in the *2020 Communications Marketplace Report*. Finally, FCC economists continued to publish in the OEA’s working papers series.

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